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VEGETATION OF THE PRESETTLEMENT FORESTS OF NORTHERN NEW ENGLAND AND NEW YORK

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ABSTRACT. The lotting surveys from northern New England and New York provide a unique opportunity to derive quantitative documentary evidence on past forests. Due to the distinctive "proprietory town" land tenure system, northern New England has an extensive and virtually untapped archive of land division surveys done prior to settlement (1763–1820). I searched archives throughout Vermont, New Hampshire, and northern New York and located records from 179 towns documenting 48,260 individual trees across the region. Surveyors used 131 separate vernacular names representing at least 49 recognizable species. This collection of town-wide witness tree relative frequencies is a consistent and unbiased empirical estimate of the composition of the natural vegetation before confounding land use. Five ubiquitous taxa (beech, spruces, maples, hemlock, birches) comprised 79% of the witness trees. Beech (32%) consistently dominated the region with greater than 60% of the trees in some towns. Spruce (14%) was the second most abundant species and found throughout the region. Maples (12%) were consistently distributed with peak abundance in Vermont. Hemlock (12%) had a patchy distribution with pockets of abundance, including the eastern Adirondacks. Birches (9%) were a species group with higher abundance in the mountains or to the north. White pine was consistently uncommon with very low (<1%) abundance on the uplands. A dramatic "oak–beech" tension zone or ecotone separated the oak–pine vegetation in the major southern valleys from the spruce–maple–beech composition northward. The central tendency was toward spruce–hardwoods with distinctive variants in the north, the Taconics, and the Champlain Valley. Major fires and blowdowns were equally rare and affected only 0.5% of the region. Fire was frequent only in the Hudson-Champlain corridor and windthrow was a low-level background disturbance. The most dramatic changes documented over the past 200 years have been the decline of beech and the profound effects of human land use.

Key Words: Adirondacks, historical ecology, New Hampshire, northern hardwood forest, plant biogeography, presettlement vegetation, proprietory town, surveyor's records, Vermont, witness tree

The first Europeans in northeastern North America saw the forest as "daunting terrible . . . infinite thick woods" (Josselyn 1675). Historical views of the land are subjective and anecdotal, but we are still influenced by their lasting metaphors: "This is the forest primeval. The murmuring pines and the hemlocks/ Bearded with moss, and in garments green, indistinct in the twilight/ Stand like Druids of eld, with voices sad and prophetic" (Longfellow 1854). Indeed the 18th century was *le grand dérangement* for both the people and forests of Acadia and New England. The 1700s began the clearing and harvesting of upland New England and within a century the land was profoundly changed (Whitney 1994). Since much of the region is forested today, we often assume a similarity to, if not continuity with, forests of the past. Was the forest dominated by the pines and hemlocks of Longfellow or the "hemlock–white pine–northern hardwoods" of Braun's (1950) classic treatise? Was the vegetation the thick woods of Josselyn or filled with decadent behemoths of "old growth" stands? Were the "bearded" trees long undisturbed and waiting to die of old age? Reconstructing the nature of the "primeval" forests is not just an academic exercise in historical ecology, but is necessary to establish an empirical baseline for ecological, educational, and management activities.

The characteristics of present forests can be projected backward to elucidate the composition and structure of historic forests. The response of trees to environmental factors or the current composition of long undisturbed forests are potential models for past conditions. Each of these models has limitations. Correlation with environmental variables is usually linear and deterministic. It tends to produce broad zones of vegetation responding to a single factor (e.g., climate) or stereotyped vegetation types based on distinctive topography or substrates. More appropriate models would be more sophisticated (i.e., non-linear, multivariate, stocastic) and be spatially explicit (e.g., Pacala et al. 1993). In addition, environmental conditions, especially in glaciated regions, are not a constant background and shift (e.g., climate) or develop (e.g., soils) in the interim. Paleoecological studies show the vegetation in northern New England is in flux due to long- and short-term environmental changes, land use history, and stochastic factors (Jacobson 2000).

A more practical approach to extrapolation is to use surviving forest remnants, especially those unconfounded by human activities. Even the largest of these areas in the Northeast (e.g., The Nature Conservancy's Big Reed Forest Reserve in northern Maine, The Bowl Research Area in the White Mountain National Forest of New Hampshire, and the Five Ponds Wilderness of the

Adirondack Park in New York) are few in number, have been repeatedly naturally perturbed (i.e., wind, ice, insects, fire), and escaped human activities exactly because they were "odd-balls" or "out-of-the way" (Cogbill 1996). Remnants, by definition, have escaped expected disturbances and are necessarily atypical of the "normal" or prevailing "common" landscape at any time.

Since the nature of the primeval forest is shrouded by myths, unrealistic models, and atypical remnants, historical methodology must be used to discover their reality. Actual "eye-witness" accounts are needed to document the details, variation, and dynamics in the landscape. Contemporary observations of explorers, naturalists, diarists, authors, and publicists abound, but they are very subjective and generally qualitative (Whitney 1994). Paleohistorical studies are more scientific and "see" the forest through reconstruction. They examine the physical evidence from earlier forests (e.g., dead wood, charcoal, pollen, macrofossils) at a site, testifying of the past occupants. Regional paleoecological syntheses give a long-term and relatively low resolution history of regional vegetation (Jacobson 2000; Spear 2000). We do not, however, have to resort only to scientific studies of remains to discover aspects of the vegetation that covered the historic landscape. Although the trees are no longer available for scientific inquiry, there is a contemporary and empirical documentary record. Surveyors at the time actually saw and recorded forest composition during land division and survey (Whitney 1994). Early surveys from northern New England, generally 1763 to 1820, clearly document the actual, not theoretical, abundance of particular trees in the forest before human improvements.

A distinctive land tenure system arose in the 18th century in the northern English colonies in North America (Clark 1983; Price 1995; Woodard 1936). The unsettled lands in northern New England were divided into areas, ideally six miles square on a side (= 100 km^2), called "towns." The "outlines" of the towns were commonly surveyed in anticipation of settlement and then the land was granted by the crown or the colonial government to a group of persons "in common," so-called "proprietors." The main occupation of the absentee proprietors was to subdivide the town into "lots," survey those (typically 40–60 ha) lots, and transfer ownership by means of a "lottery" among shareholders. Surveyors traditionally documented distances and corners of the outlines and lot boundaries by blazing and recording trees ("witness trees"). An unintended consequence of this "lotting survey" was a sample of the trees in the town on a predetermined grid. Significantly, the surveyors also often recorded general forest conditions, the suitability for settlement, and unusual character of each lot.

The proprietory town system was continued by the New England states after independence until disposal of ungranted land was completed in the mid-1800s. In northern New York much of the land was not granted to proprietors, but starting about 1791 the various units (i.e., tracts, purchases, patents) were transferred to individuals by the state (McMartin 1994). Significantly, in the Adirondack region, many units or subdivisions called "townships" were nominally the same size (100 km^2) as the New England town. Although most of the New York tracts do not correspond to towns today or were never settled, many were surveyed by the state into lots in the proprietory town tradition. Taken all together, these surveys inadvertently produced a systematic and widespread sample of the forest of northern New York and New England in the late 1700s and early 1800s ("presettlement surveys"). These records are official documents, but the local and transitory nature of the proprietors resulted in the manuscript lotting surveys, typically recorded in the "Proprietors' Book," or the resultant maps being scattered in various repositories. The New England town lotting methods were incorporated into the Land Ordinance of 1785, which mandated the "rectangular system" for land division in the western United States (Price 1995; White 1984). The resultant federal General Land Office (GLO) surveys have been the primary resource for numerous studies of the historical landscape (e.g., Delcourt and Delcourt 1996; Schwarz 1994; Whitney 1994).

Not as formalized as the GLO surveys, the unstandardized and dispersed town proprietors' surveys have received remarkably little interest (cf. Bourdo 1956; Irland 1999; Whitney 1994). In the Northeast, studies of the presettlement surveys have been done in northern Vermont (Siccama 1971), northern Maine (Lorimer 1977), upstate New York (Marks and Gardescu 1992; McIntosh 1962; Seischab 1990, 1992) and eastern Canada (Lutz 1997; Moss and Hosking 1983). All these studies used town outline surveys, except Siccama (1971) who used lotting surveys within 6 towns in northern Vermont to look at local vegetation patterns. In contrast, there are several towns in both New Hampshire and

Connecticut with readily available manuscript maps or other summaries of lotting surveys (Cogswell 1880; Hamburg and Cogbill 1988; Torbert 1935; Winer 1955). In addition, several researchers at Harvard Forest have begun to analyze town-wide lotting surveys in over 40 towns in southern New England (Foster et al. 1998; M. Burgi, pers. comm.). Whitney (1994) integrated many of these surveys into maps depicting the pattern of species' abundances over the northeastern quarter of the United States. His small-scale maps show broad continental distributions within the Northeast. The wealth of information from the underutilized and numerous town surveys is an unparalleled opportunity to fill in geographic gaps in coverage and display details of species distributions. Thus this study's purpose is to locate, collate, and summarize the available town witness tree surveys to derive a quantitative empirical database on the presettlement vegetation and its variation over northern New England and New York.

MATERIALS AND METHODS

I searched archives throughout Vermont, New Hampshire, and New York to locate manuscripts, maps, and published records of lotting surveys before settlement. The collation of witness trees in the presettlement surveys resulted from three separate projects. The Vermont collection was commissioned by the Vermont Biodiversity Project to provide background for the classification of vegetation in the state. The majority of the recorded surveys found were in the Proprietors' Books typically housed with the town land records in their respective Town Halls. Copies of many of the early town records are on microfilm at the Public Records Office in Middlesex. In addition, surveys of the towns granted by colonial New York within the present borders of Vermont were found in the New York State Archives (NYSA) in Albany. In the 1790s, the leased lots in the Rensselaer Manor towns adjacent to Vermont were also surveyed using similar techniques (Rensselaerwyck Papers, NYSA). The New Hampshire surveys were collected in a collaboration between the Hubbard Brook Long-Term Ecological Research (LTER) and the Harvard Forest LTER projects to create a baseline for historical land use studies. New Hampshire surveys were also usually recorded in the Proprietor's Books, commonly housed in the town office. Microfilm copies of many town records in New Hampshire were found at the New

Hampshire State Library in Concord. I collected the New York surveys in a follow-up project to document further the characteristics of old growth forests in the Adirondacks (Woods and Cogbill 1994). The New York records were found in the state's collection (NYSA) of Field Books (also available from the LDS [Mormon] Family History Centers) or Surveyor General's Books. Other sundry surveys and summary maps were collated from published papers and from manuscripts in various repositories (Town offices, State Historical Societies, State Archives, State offices) in all three states.

Records containing witness tree data or descriptions of the forest were carefully read, noting all trees cited by name and any descriptions of the forest composition or its disturbance (e.g., "open", "burnt", "fallen"). Throughout proprietary lotting surveys, virtually all witness tree citations were of a single tree at each sample point, so species associates were only known from supplemental line or lot descriptions. Whenever possible the trees were located on a map of the original lots ("lotting map" or "town plot"), and a special effort was made to avoid duplication of trees on shared boundary lines or the corners of adjacent lots. All witness tree "mentions" within each town were classified and tallied by the most exact taxa inferred by the surveyor's name. When possible, appropriate taxa were combined and frequencies summed into functionally similar groups (e.g., soft maples, white oaks, hard pines, wet ashes, white birches). In order to maintain a consistency in the identifications across all towns, the taxa and their frequencies were further lumped into 26 exclusive genera groups. For each town with more that 50 witness trees, the relative frequency of each taxon was treated as the presettlement composition (ca. 1800) at that location. To reveal the distribution pattern of each group or taxon, the relative frequencies were plotted on basemaps using Street Atlas USA® (DeLorme Co., Yarmouth, ME). Following Whitney (1994), isopleths of equal witness tree frequency ("isowits") generalize the patterns within the region.

Due to availability of wide ranging and detailed presettlement surveys, the forest was arguably better documented before settlement than it is today. The most detailed current data on the forest composition is in the decennial Forest Inventory and Analysis (FIA) project of the United States Forest Service. A comparison of these two data sets highlights changes over the past 200 years.

I calculated the ratio of the 1983 Vermont FIA (Frieswyk and Malley 1985) relative density of trees (> 5 in. DBH) to the average witness tree frequency in equivalent species' groups in the state ca. 1800.

RESULTS

This study located 179 "towns" in northern New England and New York with extensive lotting surveys (Table 1). The proprietory surveys date primarily from 1763 to 1810. Some non-proprietory towns' lots were surveyed as early as 1673 (Clark 1983), while late-granted tracts in the mountains were surveyed as late as 1850. In Vermont and New Hampshire the Proprietor's Books have survived in at least 185 (37%) of the towns and 105 (57%) of these books contain numerous witness tree mentions. Although 21 other town witness tree records were uncovered, the vast majority (83%) of the New England surveys were from the proprietors' records themselves. Due to the more exhaustive searches, Vermont has a slightly higher "yield" of books or surveys than New Hampshire; at least 33% of the Vermont towns have surviving presettlement surveys. In New York's Adirondacks, 49 (37%) of the larger tracts and townships have equivalent surveys available. The towns in the witness tree database come from throughout the region. There is the greatest representation from the heavily settled Merrimack Valley and western Vermont towns and the least representation from east-central New Hampshire and southeastern Vermont towns. Overall 48,260 witness trees were tallied with a median of 179 trees in a town and a rough sample density of 2.7 trees per km^2.

Vernacular names. In 1609, Samuel de Champlain (1925) saw ". . . fine trees of the same varieties (*espèces*) we have in France" along the New York shore of Lake Champlain. Although the early European observers were familiar with the genera in the flora of eastern North America, the species were novel. Surveyors invariably used colloquial names for trees, but virtually all citations can be associated with known scientific taxa. The lack of Latin names is not surprising given the short time since the introduction of the Linnaean system in 1753 and lack of useful manuals or floras until the turn of the century. Despite their isolation and lack of formal botanical education, the surveyors were

Table 1. Number of towns and witness trees represented in existing surveys from Proprietors' Books and other archival documents.

Region	Current Number of "Towns"	Number of Towns with			Survey Dates	Number of Witness Trees
		Prop. Book	Prop. Book Lotting	Total Lotting		
New Hampshire	245	77	35	44	1673–1850	16,781
Vermont	251	108	70	82	1763–1820	21,150
Adirondacks	132	—	—	49	1771–1831	8960
Taconics	4	—	—	4	1790–1795	1369
TOTAL	628	195	105	179	1673–1850	48,260

Table 2. Cited tree names in presettlement (1763–1820) forest surveys from 179 towns in Vermont, New Hampshire, and northern New York. Brackets indicate possible taxonomic ambiguity. Nomenclature follows Gleason and Cronquist (1991).

Surveyor Name	Surveyor Synonyms	Spelling Variant	Taxa Referenced
Generic Names			
Ash			*Fraxinus* sp.
Birch		Burch, Berch, Birtch, Burtch	*Betula* sp.
Spruce	Black spruce		*Picea* sp.
Cherry	Wild cherry		*Prunus* sp.
Elm		Holm, Ealm	*Ulmus* sp.
Hickory			*Carya* sp.
Maple		Mapel, Maypole, Mepall	*Acer* sp.
Oak		Oke, Oake, Och, Ock, Ocke	*Quercus* sp.
Pine			*Pinus* sp.
Poplar		Popler, Popular, Popplr	*Populus* sp.
Shadwood		Shadbush	*Amelanchier* sp.
Thorn bush	Hawthorn		*Crataegus* sp.
Willow	Osier, White willow		*Salix* sp.
Specific Names			
Alder	Alder birch		*Alnus incana*
Apple			*Pyrus malus*
Basswood		Bass, Baft	*Tilia americana*
Beech		Beach, Bectch	*Fagus grandifolia*
Black ash	Brown ash, Yellow ash		*Fraxinus nigra*
Black birch	Cherry birch		*Betula lenta*
Black cherry			*Prunus serotina*

Table 2. Continued.

Surveyor Name	Surveyor Synonyms	Spelling Variant	Taxa Referenced
Blue beech	Water beech		*Carpinus caroliniana*
Boxwood	Box tree		*Acer negundo?*
Butternut	White walnut, Lemon walnut, Oylnut, Oilnut, Butterwood	Butnut, Buternut	*Juglans cinerea*
Buttonwood	Sycamore	Buttinwood	*Platanus occidentalis*
Cedar	White cedar		*Thuja occidentalis*
Chestnut		Chisnut, Chesnutt	*Castanea dentata*
Chestnut oak	Rock oak, Yellow oak		*Quercus prinus*
Fir	Balsam fir	Firr, Fur	*Abies balsamea*
Hemlock	Hemlock pine	Hamlock, Hemloc	*Tsuga canadensis*
Leaverwood		Lear wood, Liverwood	*Ostrya virginiana*
Moosewood	Moose willow, Moose maple, Moosebush, Stripped willow		*Acer pensylvanicum*
Mountain ash		Mt. Ash	*Sorbus americana*, [*S. decora*]
Norway pine	Red pine		*Pinus resinosa*
Pepperidge		Pepraige	*Nyssa sylvatica*
Pin oak			*Quercus palustris*
Pitch pine		Pich pine	*Pinus rigida*
Popple		Pople, Popel, Poppel	
Red ash		Read ash, Reed ash	
Red birch		Read burch	*Betula cordifolia*, [*B. alleghaniensis*]

Table 2. Continued.

Surveyor Name	Surveyor Synonyms	Spelling Variant	Taxa Referenced
Red cedar			*Juniperus virginiana*
Red cherry		Reed cherry	*Prunus pensylvanica*
Red elm			*Ulmus rubra*
Red oak		Read oak, Reed oak, Reid oak	
Sassafras		Saxefax	*Sassafras albidum*
Shagbark	Shag walnut		*Carya ovata*
Soft maple	Red maple		*Acer rubrum*, [*A. saccharinum*]
Spruce	Double spruce, spruce pine	Sprusse	*Picea rubens*, [*P. mariana*]
Sugar maple	Hard maple, Rock maple, Sugar tree, Black maple		*Acer saccharum*
Swamp maple			*Acer rubrum*, [*A. saccharinum*]
Swamp white oak		Swamp oak	*Quercus bicolor*
Tamarack	Hacematac, Larch	Tamarac, Tamarisk	*Larix laricina*
Water ash			*Fraxinus nigra*
White ash			*Fraxinus americana*
White birch		White burtch	*Betula papyrifera*, [*B. cordifolia*]
White elm			*Ulmus americana*
White maple	Silver maple		*Acer saccharinum*, [*A. rubrum*]
White oak		Whight oak, Whit ocke	*Quercus alba*
White pine			*Pinus strobus*
White spruce			*Picea glauca*
Yellow birch			*Betula alleghaniensis*

Table 2. Continued.

Surveyor Name	Surveyor Synonyms	Spelling Variant	Taxa Referenced
Yellow pine			Pinus rigida, [*P. resinosa*]
Ambiguous Names			
Balsam			*Abies balsamea, [Populus balsamifera]*
Bastard maple			Acer spicatum, [*A. pensylvanicum*]
Hornbeam			*Ostrya virginiana, [Carpinus caroliniana]*
Juniper			*Juniperus virginiana, Thuja occidentalis*
Moose elm			*Acer pensylvanicum*
Peach			*Prunus*?
Plum			*Prunus* sp.
Rock birch	Rock white birch		*Betula* sp.
Wild pear			*Prunus* sp.
Witch elm			*Ulmus rubra, U. americana*
Whitewood			not *Liriodendron, Populus deltoides*?
Deceptive Names			
Black oak			*Quercus rubra, [Q. velutina]*
Dogwood			not *Cornus*?
Hacmetack			*Picea rubens, [Larix laricina]*
Walnut			*Carya* sp.
Witch hazel	Hazel, Hazelnut		*Ostrya virginiana*

Table 2. Continued.

Surveyor Name	Surveyor Synonyms	Spelling Variant	Taxa Referenced
Enigmatic names			
Beattlewood			?
Bilberry tree			?
Greenwood			?
Jerwood			?
Laurel			*Kalmia latifolia*?
Pegwood			?
Remmon		Remmond, Ammon, Remon	?
Roundwood			*Sorbus* ?
Shittum wood			*Sorbus* ?
Spoonwood bush			?
Tobaccowood	Moose(wood)		*Acer pensylvanicum* ?
Wicerpee			not *Dirca*

competent naturalists. The early lotting surveys recorded 131 vernacular tree names or synonyms (excluding quaint spellings) representing 65 distinct taxa (Table 2). Interestingly, the colloquial names were influenced by transferred English usage, and so the most ambiguous attributions are in taxa not shared with the British flora (i.e., *Ostrya, Carya,* shrubby *Acer*). The surveyors were very discerning and consistent in usage. For example, they often made subtle species distinctions (e.g., red ash, red elm). Overall 49 recognizable species are found in the presettlement species list for the 179 towns (Table 2). All these cited species are prominent current members of the approximately 65 species in the region's tree flora. Several infrequent species were not explicitly acknowledged (e.g., bur oak, big-toothed aspen, grey birch, bitternut hickory), but they are certainly present, submerged in amorphous genera or by misunderstood terms. There have been no apparent extirpations, but some terminology (e.g., lemon walnut, leaverwood, pepperidge) has fallen out of use.

Although the surveyors used many explicit vernacular names, there are still various degrees of uncertainty in some species (Table 2). For many of the most common trees only a generic name was cited (i.e., maple, oak, pine, birch, ash). In these genera there is an unavoidable confusion of species, but within their range and proper habitat many of the common species are unambiguous (i.e., sugar maple, red oak, white pine, yellow birch, white ash). Even in context, in some genera (i.e., cherry, poplar) the cited species remains ambiguous. Some specific names are still equivocal (e.g., swamp maple, yellow pine, red birch) or are occasionally misapplied (i.e., balsam, hornbeam, juniper). The most confusing are anachronistic names that have a deceptive common meaning today (cf. Marks and Gardescu 1992; Seischab 1992; Siccama 1963). Thus in late 18th century vernacular usage, hacmetack referred to any conifer, especially *Picea,* rather than its current exclusive use for *Larix*; witch hazel was *Ostrya* rather than *Hamamelis*; walnut meant *Carya* rather than *Juglans*; dogwood did not refer exclusively to *Cornus*; black spruce included red spruce, whose species concept did not exist until the late-1800s; and black oak was regularly used for red oak. A few names remain enigmatic; those used several times might be lost vernacular terms (i.e., remmon, shittum wood, pegwood, tobaccowood), but those used a single time were more likely confu-

Table 3. Composite presettlement composition of witness trees (n = 48,260) in 179 towns in northern New England and New York.

Taxa	Constancy (%)	Mean (%)	Maximum (%)	Coefficient of Variation (%)
Beech	98.9	32.1	68.2	42
Spruces	87.2	14.2	52.6	96
Maples	99.4	12.1	33.1	51
Hemlock	97.2	11.6	39.3	73
Birches	99.4	8.8	37.8	67
Pines	60.6	4.8	56.8	177
Oaks	52.2	4.8	58.8	195
Fir	55.0	2.9	25.0	165
Ashes	78.3	2.2	11.7	94
Basswood	66.1	1.4	10.0	121
Ironwoods	57.8	1.2	9.5	149
Elms	50.0	1.0	8.2	157
Cedar	30.6	0.5	7.1	216
Poplars	33.3	0.4	4.3	198
Chestnut	10.0	0.4	12.9	406
Tamarack	16.7	0.3	12.1	362
Hickories	20.6	0.3	4.3	254
Moosewoods	21.7	0.2	3.9	264
Butternut	17.8	0.2	5.3	326
Cherries	22.8	0.2	2.4	263
Willow & Alders	18.9	0.1	1.6	262
Buttonwood	7.2	0.0	1.7	499
Mountain Ash	2.2	0.0	1.7	740
Other		0.2		

sions (i.e., wicerpee, laurel), misunderstandings (greenwood, jerwood), or inventions (beattlewood, bilberry tree, gumwood).

Species distributions. The composite composition over the 179 towns is an integrated view of the vegetation in the region in 1800 (Table 3). Five taxa (beech, spruces, maples, hemlock, birches) composed 79% of the witness trees and each occurred in virtually every town in the region. Each of these ubiquitous trees was abundant (mean > 8%), had relatively low variability between towns (coefficient of variation [CV] < 100%), and could dominate certain towns (maxima > 30%) across the region. Beech (mean 32%) was by far the most abundant species, exceeding 60% in widely scattered towns. It constituted greater than

30% of the trees throughout its range, falling off only in southeastern New Hampshire, in the high mountains, and in the far northeast. Spruce was second in abundance (14%), but still less than half that of beech. It had a more restricted range than the other dominants (constancy 87% of the towns) and was not recorded in a few towns of the Champlain, Hudson, or Merrimack Valleys. Spruce abundance was variable, reaching 15% at middle elevations across the region, 35% in the mountains, and maxima (> 50%) in the western Adirondacks and at the Canadian border. Maples (mean 12%) had an abundance greater than 6% throughout the region with high pockets (> 20%) scattered across the richer soils of Vermont. By far the majority of these maple trees consisted of sugar maple, but its abundance was necessarily less than the generic figures. An undetermined lesser percentage of the trees was red or silver maple, especially in lowlands or in the larger river valleys. Hemlock had the same mean abundance (12%), but had a more patchy distribution than maple. There were three large polygons (i.e., southwestern New Hampshire, central Vermont, and especially the eastern Adirondacks) of towns with hemlock greater than the 20% isowit. Birches were the least abundant (9%) of the dominants and this figure is inflated since the taxon is also a mixture of species. Overall birch distribution was variable with greater than 5% everywhere and maxima of greater than 25% in the mountains. These maxima are most likely due to white birch, but yellow birch was apparently most important in mid-elevations and below. Both white and yellow birch increased from south to north and upslope, and both the species were represented in all areas except the Merrimack Valley.

Pine and oak were found in slightly more that half of the towns. Both had low overall abundance, but in a restricted part of their range could dominate (maxima > 55%) certain towns (Table 3). Oaks (mean 5%) were commonly found only in the Champlain or large southern valleys. Oak was codominant (> 30%) with pine in the Merrimack Valley and was commonly abundant (> 15%) in the Taconics and Hudson-Champlain corridor; however, these were a mixture of oak species. In lowland valleys, areas of maximum oak abundance, white oak dominated, with high frequencies even at the northern limit of its range (13%) on Squam Lake, New Hampshire. Red oak was most abundant (to 25%) in the southern hills and valleys and scattered (< 5%) northward in the upper valleys, but not found on the uplands or in the mountains.

Pine (mean 5%) also showed a variable and restricted distribution (Figure 1). The 5% isowit bounds roughly three polygons: in the Hudson-Champlain corridor, southeastern New Hampshire, and the Connecticut River. The nested 20% isowit defines the high pine abundance in scattered pockets in the Champlain, Connecticut, Ausable, and Saco Valleys and a large extreme (maxima > 50%) area in the Merrimack Valley. Unfortunately, the distribution and composition were obscured by the lumping of pines (i.e., pitch, white, red) into a single group. In areas of maximum representation in the large southern valleys, the majority of the pattern is clearly due to pitch pine, as here it was regularly cited by name or as "pine plains". White pine co-occurred in these valleys and was probably most common in northern ones, particularly the Champlain Valley and the "Cohas" (Abenaki for "white pine place") in the upper Connecticut Valley (Whitney 1994). Evidently white pine was the only pine on the uplands outside of the Taconics; but remarkably, here on the hills and mountains, white pine was consistently uncommon with very low (< 1%) abundance. Despite its reputation and conspicuousness, white pine was a relatively minor component of the presettlement forest in most of northern New England (cf. Braun 1950; Clark 1983; Irland 1999; Pike 1967).

In addition to the seven most abundant trees, five other taxa (fir, ashes, basswood, ironwoods, elms) occurred in more than half of the towns (Table 3). All these secondary species had low average abundance (1–3%). Except for fir, which could be locally common (> 20%) in the mountains, these species were common associates of the dominants and had rather modest maximum expression (8–12%). Ash was the most widespread (78% of the towns), but its component species showed contrasting distributions: black ash was more northern and in the lowlands, white ash more in the uplands and southern, while red ash was less common and intermediate. The remaining secondary species (basswood, ironwood, elms) were scattered across the region, but each reached maximum abundance in the richer lowlands such as the Champlain Valley.

The rest of the trees in the flora were recorded in less than 33% of the towns (Table 3). All these infrequent species, including the minor species in the grouped genera, had low average

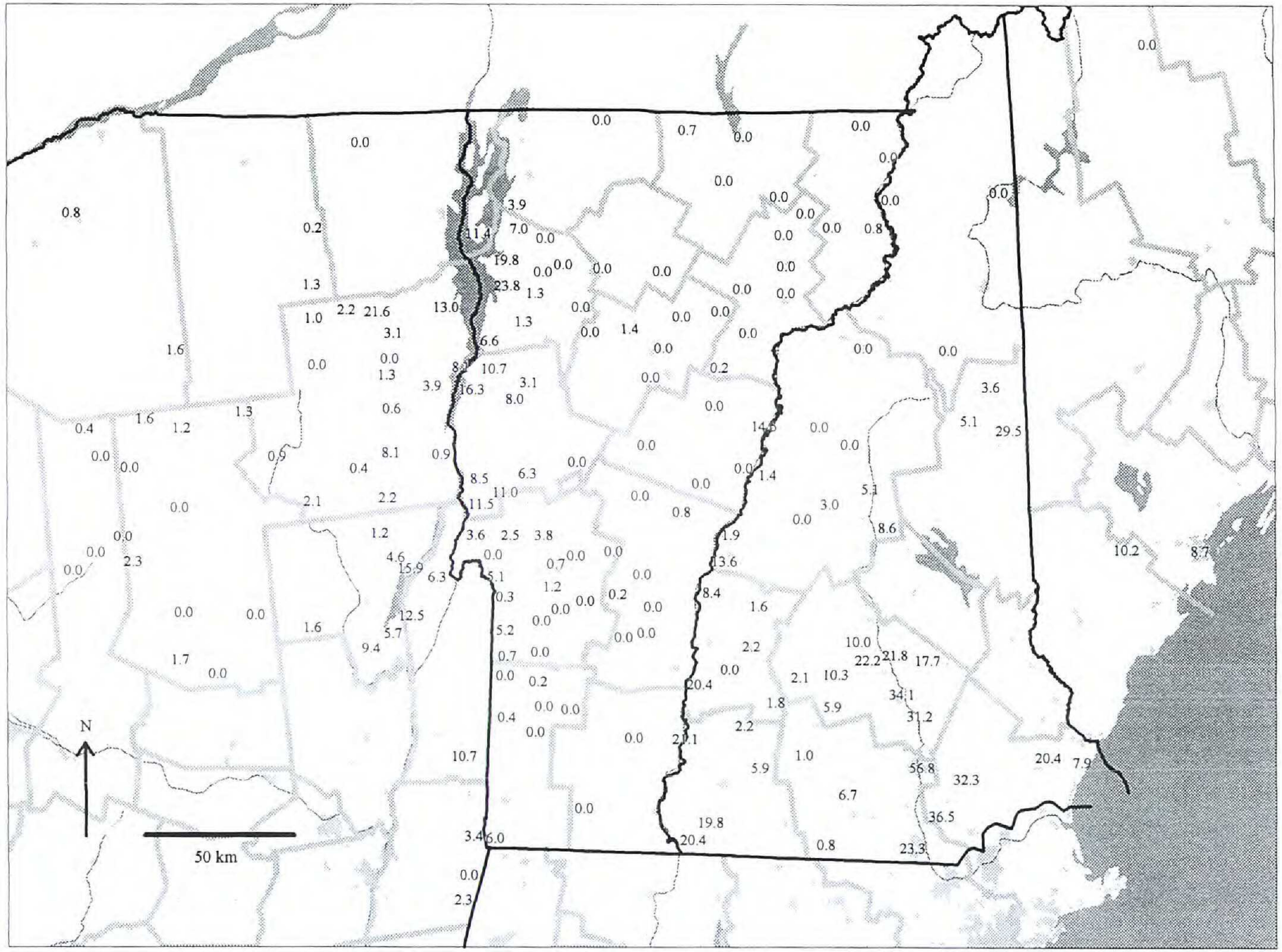

Figure 1. Relative frequencies (%) of pine in 179 town-wide presettlement lotting surveys in northern New York, Vermont, and New Hampshire. Base map is ® 1996 DeLorme Co., Yarmouth, ME.

Table 4. Number of towns (out of 179 surveyed) and lots affected by cited disturbances in presettlement surveys (1763–1820) in Vermont, New Hampshire, and northern New York.

Region	Total No. of Towns Disturbed	Fire		Windfall	
		Towns	Lots	Towns	Lots
New Hampshire	4	2	2	2	2
Vermont	8	2	2	6	10
Western Adirondacks	6	1	1	5	32
Eastern Adirondacks	14	13	71	4	6
Lake George	5	5	22	2	5
TOTAL	37	23	98	19	55

abundance (< 0.5%) and very patchy distributions (CV > 200%). Many of these minor species were restricted to special habitats (i.e., swamps, dry ridges, sand plains, riparian galleries, mountain slopes) and only three (chestnut, tamarack, cedar) with modest maximum abundance (> 6%) were locally common in particular habitats. Despite being distinctive indicators in the flora, all the remaining minor species averaged less than 1.2% abundance even when present, and were inconsequential to the prevailing composition of the forest

Dynamics. The presettlement surveys provide a static view of the forest development at the time, but the surveyors also indicated past disturbances in the forest. Lotting surveys commonly included "dead" or "dry" trees and "stubs" or "stumps" indicating a consistent low level of disturbance. The resulting forest often had numerous "staddle" (sapling) trees cited, but trees very rarely became large enough to merit the surveyor's "great" modifier. Significantly, there were 153 lots with instances of larger "burns" or "windfalls" worth recording (Table 4). Fire was the most prevalent disturbance with some two-thirds of the highly disturbed lots being burned. For example, in 1749 Peter Kalm (1987) noted that on the western shore of Lake Champlain "the mountains are covered with trees, but in some places the forests have been destroyed by fire." This is exactly the area in the Hudson-Champlain corridor where fire was most frequent. Beyond this valley, or in the under-cited Merrimack Valley, which obviously was an often burned "great pitch pine plain," fire had an extremely low frequency in the mountains of northern New

Table 5. Ratio of relative tree density in 85 towns across Vermont about 1800 to statewide FIA (Frieswyk and Malley 1985) relative tree density in 1983.

Increases (+)		Neutral		Decreases (−)	
Soft maples	25	Hard maples	1.3	Beech	0.2
White birches	23	Dry ashes	1.6	White oaks	0.2
Poplars	7	Sweet birches	1.0	Basswood	0.25
Cedar	4	Red oaks	0.9	Hard pines	0.4
Fir	4	Spruce	0.9	Wet ashes	0.4
Soft pines	2.3	Hemlock	0.7		
		Elm	0.7		

England and the western Adirondacks (Table 4). Evidently, catastrophic fires were restricted to sandy or rocky substrates, and generally near the settlement frontier. In contrast to fire, windfalls were found regularly across the region. Although commonly covering several lots at once, windfalls were smaller and more diffuse than burns. For example, in 1816 surveyor John Richards (Field Books, Vol. 4, NYSA) found "All the timber standing on it are large and thrifty, with very few exceptions, the wind has made havock [*sic*] among the timber in many places of [Township # 42]". Here in the western Adirondacks wind disturbance reached its maximum frequency (Table 4) and the pattern has been continued with the repeated blowdowns of 1950 and 1995 at the same site. As a result of the clumped and restricted distribution of burns, an equal number of towns was affected by fire (13%) as by wind (11%). Overall disturbances large enough to deserve mention, however, affected only 21% of the towns. In the affected towns an estimated 2.5% of the area was in burns or windthrow; overall roughly 0.5% of the region was affected by major disturbances at settlement.

The presettlement forest composition is a unique baseline for documenting the effects of land use in the region. Although all the species of the early forest were still prominent by 1983, the composition of the forests in Vermont have changed dramatically since 1800 (Table 5). Species of younger forests associated with the aftermath of human activities (i.e., soft maples, white birch, poplars) have increased by two orders of magnitude (up to 2500%). Even white pines have more than doubled in frequency, apparently due, in part, to the net gain between the loss due to harvesting and the regrowth in abandoned fields. Several species that originally grew in richer lowlands (i.e., white oaks, basswood, wet ashes) have also declined substantially (down to 20% of the original). Their maximum abundance was on the most productive land, which was intensively cleared and often remains unforested today, such as the Champlain Valley. Several species have remained roughly unchanged over the 200 years. Some of this is a balance between harvesting and woodlot improvement (maple) or a natural tendency for regeneration (ashes, sweet birches). Spruce has had substantial decline at mid-elevations due to climatic changes and forest harvesting, but this loss has been nearly balanced by substantial gains in the valleys due to regeneration in old fields (Hamburg and Cogbill 1988). The most dramatic change over the past 200 years is the loss of the absolute dominance of beech to 20% of its presettlement abundance. This decline is apparently not due to recent bark disease, to over utilization for wood, to lack of regeneration, or to land clearance. As first pondered by Siccama (1963, 1971), the reason for the incredible amount of beech in all northeastern presettlement surveys, and its subsequent decline, remains an enigma.

DISCUSSION

Accuracy. Quantitative analyses of the survey records depend on the data being an accurate estimate of tree composition within the towns. Lotting and outline surveys of proprietory towns are not a random sampling of the trees at the time; however, the survey design did produce samples in quasi-regular pattern at locations determined *a priori* and covering the whole town. As with much historical data, the methods were poorly documented, coverage was incomplete, and the observations were uncontrolled. For example, in 1772 in surveying the town of Mansfield, Vermont, Ira Allen (1928) professed that "(a) great proportion of said lots were made on spruce or fir trees, and if I described them as such, it would show the poorness of the town. In my survey bills I called spruce and fir gumwood, a name not known to the [proprietors]". Contrary to his claim, Allen's own proprietors' survey (Mansfield Proprietors' Book, Stowe [VT] Town Hall) shows 18% spruce and no "gumwood" at all. Nevertheless, the proprietor's surveys were done by numerous surveyors, over many years, with little incentive to skew the results.

In northern Vermont outline surveys, the corner-to-tree distances were statistically equal for all major species (Siccama 1971). Apparently in these systematic surveys there was little bias in the choice of trees (Bourdo 1956; Whitney 1994) and spatial bias, if any, was toward the more detailed surveys (e.g., lower reaches of the towns with the smallest lots), exactly the areas in town later most affected by settlement. At face value, the lotting tree tallies are a statistical sample and the relative frequencies are a consistent and unbiased estimate of overall composition of the forests at the turn of the 1700s.

Vegetation scale. The patterns of tree distribution exist at three distinct, albeit nested, vegetation scales: the community or forest type ($\sim 10^{-2}$ km^2), the landscape or local combination of communities ($\sim 10^2$ km^2), and the regional or zonal arrangement of these landscapes ($\sim 10^5$ km^2). The town grain size (nominally 10^2 km^2) is fixed by the mechanics of the presettlement surveys, but conveniently preserves species variation at the landscape scale (Delcourt and Delcourt 1996). The town-wide sample necessarily averages tree abundance over multiple forest types, but is an ideal size to reflect the local proportion of trees in those types. Thus the town sample is appropriate for the characterization of the landscape composition and advantageous for quantifying regional patterns. The minimum of 50 trees per town is low (Bourdo 1956) and limits the detection of infrequent species. Restricted types or infrequent species are incompletely sampled, but the analyses are accurate for the common species responsible for gross vegetational patterns. Moreover, many of the towns had large samples (> 400 trees) and this accounts for some estimates of range and abundance of uncommon species.

In mountainous or hilly terrain each town captured much of the elevational variation, so the town-wide data tend to cloud any elevational gradients. Moreover, each town supported many of the species in the region in a range of communities. Thus within-town variability was high compared to between-town variability. Therefore it is advantageous to have multiple samples within biophysical regions to elucidate regional patterns. The 179 towns in the region showed major range and abundance distributions not seen in the previous isowit maps derived from only 14 samples (Whitney 1994). Although the gross levels of common species abundance are similar, spatial and quantitative resolution is missing. For example, the small-scale maps (Whitney 1994) misrepresent the actual patterns: the oak dominance in the Merrimack Valley, the lack of pine on the uplands, the large amount of hemlock in the eastern Adirondacks, and the substantial presence of spruce in southwestern New Hampshire.

Vegetation types. The vegetation of the region varied from oak–pine in the warm southern valleys to beech–maple to spruce–fir in the northern mountains. In 1741, Richard Hazzen (1879), while surveying the northern boundary of Massachusetts near Whitingham, Vermont, found the land "exceedingly good and covered with Beach, Maple, Chestnutt &c. . . . the pigeon's nests were so thick that 500 might have been told on the beech [and] Hemlocks as well." The beech, maple, and hemlock still dominate, but the chestnut has been functionally eliminated and the pigeons are gone completely. At the opposite extreme of the compositional gradient, John Richards (1816, Field Books, Vol. 4, NYSA) while surveying Townships # 42 and 43 (now Five Ponds Wilderness) in the western Adirondacks saw "much fine spruce, yellow birch, beech, and maple . . . with few white pine and black cherry trees . . . [and an] abundance of the finest spruce and yellow birch on this land of any perhaps in the world." This was and remains the archetype of a red spruce–hardwood landscape in the Northeast. Even in this mixed-hardwood vegetation there was much local variation. The richer sites had more maple and less spruce. Thus in 1773 in Norbury, New York (now Calais, Vermont), Samuel Gale (Surveyor's General Book, Vol. 38, NYSA) found "choice land timbered with maple, beech, bass, some elm, ash, birch & in patches some butternuts, with Maidenhair and some nettles."

The ranges of the five dominant taxa in northern New England and New York overlapped in a broad zone, but they did not form a single landscape pattern. In the presettlement forest, beech was predominant and formed a series of conifer–northern hardwood types. Significantly, spruce was the typical conifer and neither white pine nor hemlock typified the entire zone (cf. Braun 1950). Although there were distinct regional variations (e.g., maple in Vermont hills, spruce in the western Adirondacks), numerous towns from all three states had a spruce–maple–beech composition. However common this central type, admixtures of secondary species caused the vegetation composition to diverge from this hub in three primary directions. One spoke was toward colder moosewood–fir–spruce towns of the north, the mountains, or the western Adirondacks; the second spoke was toward drier chestnut–hickory–poplar–oak ridges of towns in the Taconics-Lake George region; and the third spoke was toward the oak–pine lowland towns of the Merrimack Valley. Within this primary pattern, there were prominent variations, such as the abundance of hemlock in the eastern Adirondacks or the rich hardwoods (i.e., ashes, butternut, buttonwoods) of the Champlain Valley.

The one major vegetation boundary was the dramatic discontinuity between beech dominance on the uplands and oak–pine dominance in the major southern valleys. This rapid transition is akin to the "tension zone" between the prairie woodlands and the northern forest in Wisconsin (Curtis 1959). The similarity might even extend to the role of fire in maintaining the boundary. In the lower hills of the Taconics and southwestern New Hampshire there was an equivalent "oak–beech" tension zone at the edge of the Hudson and Merrimack Valleys. This ecotone marked a switch in dominance, as well as the coincidence of the general range limits of spruce, yellow birch, white oak, chestnut, and pitch pine. This major vegetation shift over a relatively short distance was even more surprising given the moderate elevational relief. A less distinct version of this tension zone ("pine–spruce") extended around the Champlain Valley and weakly up the Connecticut Valley. Due to the condensing of the elevation gradients and limited high elevation land, the distinct altitudinal ("coniferous–deciduous") ecotone was smoothed across towns in the presettlement compositions (Cogbill and White 1991).

Historical methodology. The lotting witness tree surveys from northern New England and New York are an empirical representation of the natural vegetation before confounding of land use. The presettlement dating, quantitative enumeration, unbiased estimates, and town-wide scale, are all unique advantages of this resource. Combined with the extensive available archival record, this tree composition database effectively documents the regional composition of the early forest. The summary isowits give higher resolution and temporal control than similar "isopoll" maps derived from paleohistorical sampling. This summary of regional vegetation, however, is still limited by its composite composition and landscape scale. Utilizing exact tree locations from lotting maps within individual towns would produce a truly detailed and spatially explicit view of the 18th century vegetation.

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